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New detrital zircon U-Pb ages on Neoproterozoic Tandilia sequences, Río de la Plata craton, Argentina

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INTRODUCTION

The geological evolution of Tandilia comprises mainly a juvenile igneous-metamorphic Paleoproterozoic basement named Buenos Aires Complex, which is covered by thin Neoproterozoic to Early Paleozoic sedimentary units which displays sub horizontal bedding (Fig. 1). This work is related to introduce the new detrital zircon U-Pb ages from two siliciclastic Neoproterozoic sequences called Villa Mónica and Cerro Negro Formations from the Barker region, and offer the comparison provenance analysis of these data with previous contributions in a paleogeographic interpretation.

GEOLOGY

The Tandilia Paleoproterozoic basement as a southern extension of the Río de la Plata craton, consist mainly of granitic-tonalitic gneisses, migmatites, amphibolites, some ultramafic rocks and granitoid plutons with calc-alkaline signature (Dalla Salda *et al*., 2006 and references therein). After U-Pb zircon crystals data (Hartmann *et al*., 2002) the tectonic scenario seems related to juvenile accretion (2.25-2.12 Ga) along an active continental margin, followed by continental collision (2.1-2.08 Ga). The Paleoproterozoic basement was preserved by the Brasiliano cycle. After a weathered process (Poiré and Gaucher, 2009) the Sierras Bayas Group (c. 185 m thick) is a record of a first Neoproterozoic sedimentary unit (siliciclastic, dolostone, shale, limestone rocks), superposed by Cerro Negro Formation (c.150-400 m thick, siliciclastics) assigned to Upper Neoproterozoic age (Fig. 1), and the final sedimentary transgression during the Early Paleozoic (Balcarce Formation; 90-450 m thick). The first marine transgression of the Neoproterozoic cover is the siliciclastic member of the **Villa Mónica Fm** developed over the Paleoproterozoic basement. On the other hand, in the Olavarría region it was defined the type section of the Cerro Negro Fm made up of illite-chlorite rich, green and reddish silts and shales. This unit unconformably overlies the limestones of the Loma Negra Fm. At the base of the **Cerro Negro Fm,** Leanza and Hugo (1987) described a "phosphate member". New exploration boreholes found c. 400 m of this unit (Poiré and Gaucher, 2009) characterized by reddish, greenish or brown-olive-black claystones and heterolithic facies, mainly deposited in upper to lower intertidal conditions. The Cerro Negro Fm as a record of third transgression yielded abundant acritarch fossils in organic matter rich shales. Rb-Sr radiometric data (Bonhomme and Cingolani, 1980) on diagenetic illitic shales suggest a Neoproterozoic age (c. 730 Ma). It is important to mention that the first detrital zircon U-Pb ages on the Tandilia Neoproterozoic sequences were presented both by Rapela *et al*. (2007) and Gaucher *et al*. (2008).

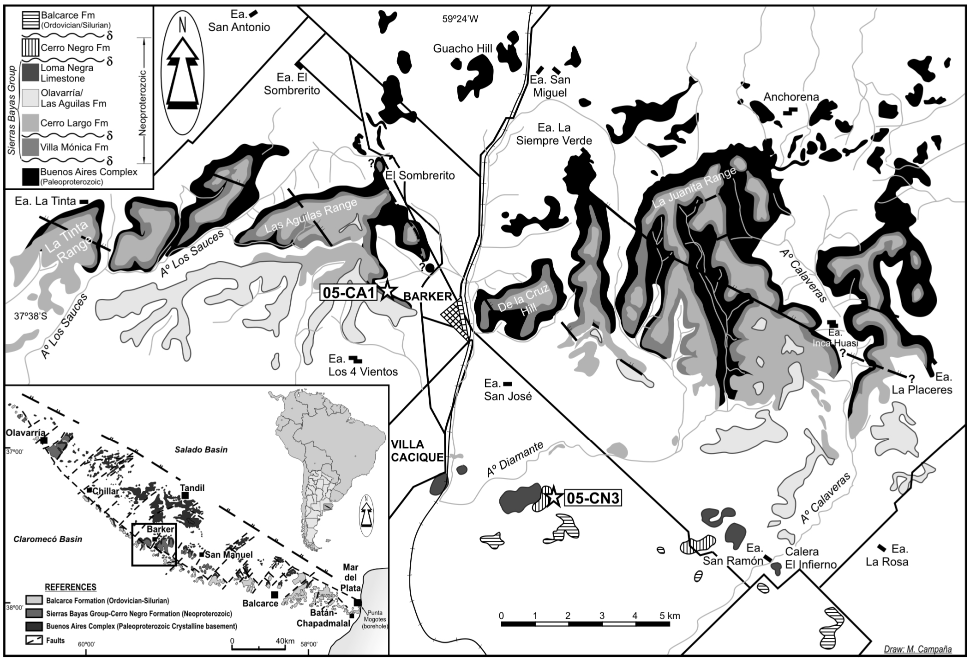

Figure 1: Geological sketch map of the Barker region and the location of the study samples. The inset shows the relative location of the area in the south-centre of the Tandilia belt. Geology based on Leveratto and Marchese (1983)

SAMPLING AND ANALYTICAL METHODS

The samples were taken from the Águilas Range outcrop of the Villa Mónica Fm near Barker town (**05-CA1**: 37º 38' 07''S-59º 24' 48''W) and from the Loma Negra quarry (**05-CN3**: 37º 41' 17''S-59º 21' 19''W) in the "phosphate member" of the Cerro Negro Fm as we show on Fig. 1. The zircons were obtained after the classical processes of crushing and sieving of about 3 to 5 kg of each sample. The fractions retained in less than 140µm mesh were separated using hydraulic processes to obtain heavy minerals pre-concentrates and treated with heavy liquids to obtain a fraction enriched in zircons. The final selection was done by handpicking under a binocular microscope. For isotopic dating, all zircon grains were mounted in 2.5 cm-diameter circular epoxy mounts and polished down until the zircons were just revealed. Images of zircons were obtained using the optical microscope (Leica MZ 125) and backscatter electron microscope (JEOL JSM 5800). Zircons were dated with a LA microprobe (New Wave UP213) coupled to a MC-ICP-MS (Neptune) at the Laboratorio de Geología Isotópica, Universidade Federal do Río Grande do Sul, Porto Alegre, Brazil.

RESULTS

The U-Pb data is shown in Fig. 2 and could be summarized as follow, taken into account that the sedimentary cover of Tandilia was characterized by four marine transgressions,

a. First marine transgression (Villa Mónica Fm): The sample analyzed here was collected at the base of the unit composed by a quartzite-type rock in the Águilas Range at the Barker region (Fig. 1). The study zircon grains have subrounded to rounded shapes suggesting an intense history transport. Sixty dated zircons yield a unimodal population with a main peak at. 2.25 Ga with typical Paleoproterozoic ages between 1.97 and 2.28 Ga (90%). These data confirm the previous one by Rapela *et al*. (2007) and Gaucher *et al*. (2008) implying that the detritus are coming mainly from the Rhyacian to Orosirian sources, commonly called in South America a "Transamazonian cycle". Detrital zircons from the Archean source are present in a 10%. The youngest detrital zircon of sample 05-CA 1 yielded an age of c. 2.0 Ga.

b. Third marine transgression (Cerro Negro Fm, "phosphate member" at the base of the unit): Fifty-eight detrital zircons were analyzed from a quartz-rich sandstone sample as we can see on Fig. 2. Zircon grains are very rounded without faces preserved; fractures are common but the crystals are complete. The frequency diagram shows a polymodal distribution pattern spanning most of the Archean, the Palaeoproterozoic, and Mesoproterozoic. The Palaeoproterozoic zircons at 2.26 to 1.7 Ga is the most important population with peaks at 2.14, 2.05 and 1.97 Ga and comprising 75 % of all dated grains. These zircon grains are coming also from Rhyacian to Orosirian sources. The Mesoproterozoic zircon peaks are at 1.53, 1.21 and 1.16 Ga and span from Calymmian to Stenian ages (20 %). Three Archean peaks (less important than the previous mentioned) span from 2.56, 2.73 and 2.90 Ga (5 %). The youngest detrital zircon of sample 05-CN 3 yielded an age of c. 1.12 Ga.

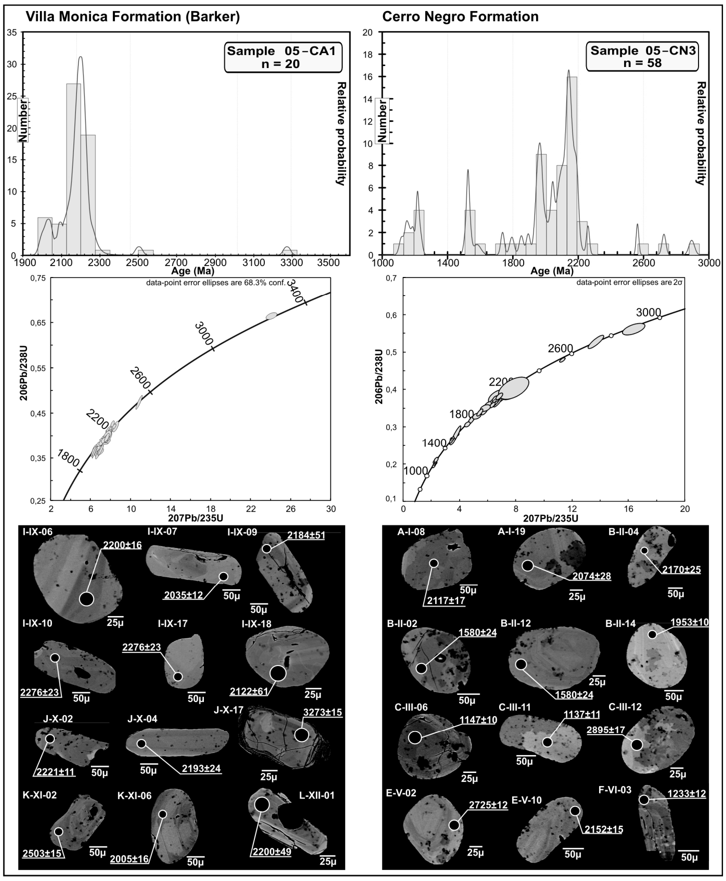

Figure 2: U-Pb Concordia diagrams for detrital zircon grains of the Villa Mónica Fm (left) and Cerro Negro Fm (right) samples. The backscattered electron images of some analyzed zircons on the bottom of both Concordia diagrams show the main typology characteristics of dated grains and LA-ICP spots.

DISCUSSION

As we can see on Fig. 3, the data for the first marine transgression **(Villa Mónica Fm)** may be compared with the data of Rapela *et al.* (2007), who report 55 detrital zircon ages for one sample from the same area. Its zircon population shows predominantly Paleoproterozoic with peak at 2.24 Ga, but it includes a subordinate Mesoproterozoic peak centred at 1135 Ma. The data published by Gaucher *et al.* (2008) are coming from a sample that was collected at the Villa Mónica Quarry which is the stratotype of this unit, about 100 km from Barker region. These authors report 81 dated zircons that yield also a unimodal population centred at 2146 Ma with typical "Transamazonian ages". Based on these coincident results it is clear that the source of the Villa Mónica Fm must have been mainly the underlying Palaeoproterozoic Buenos Aires Complex well exposed in Tandilia belt.

It is interesting to mention that the data of the third marine transgression over Tandilia belt (**Cerro Negro Fm**) could be compared (Fig. 3) with the quartz-rich sample from the underlying unit called Cerro Largo Fm (second transgression) obtained by Gaucher *et al.* (2008), these authors report more than hundred concordant zircons yielding a complex polymodal distribution spanning the Archean, the Palaeoproterozoic, and Mesoproterozoic ages. Palaeoproterozoic zircons represent the most important population and comprise 58% of all dated grains. These ages are roughly coincident with the orogenic events, recognized in Tandilia by Hartmann *et al*. (2002). It is important to note that the minor zircon population yielding Archean ages is present in Villa Mónica, Cerro Largo and Cerro Negro Fms. That confirms that these units contain in different percentages the oldest detrital zircons dated for the Tandilia region.

The most conspicuous ages of detrital zircons in the Neoproterozoic sedimentary units study here are Palaeoproterozoic, which match the widespread "Transamazonian orogenic cycle" during Rhyacian to Orosirian ages. The provenance of the Archean detrital zircons could be derived from the Nico Pérez terrane (Uruguay) where is known to contain extensive Palaeo- to Neoarchean magmatic and metamorphic rocks (Gaucher *et al*., 2008). The abundance of Mesoproterozoic zircons in the Cerro Largo and Cerro Negro samples need to be explained in a paleogeographical detail. Another striking feature to be mention is the absence of Neoproterozoic zircons suggesting that this region may be a passive margin of the Pan-African-Brasiliano Cycle.

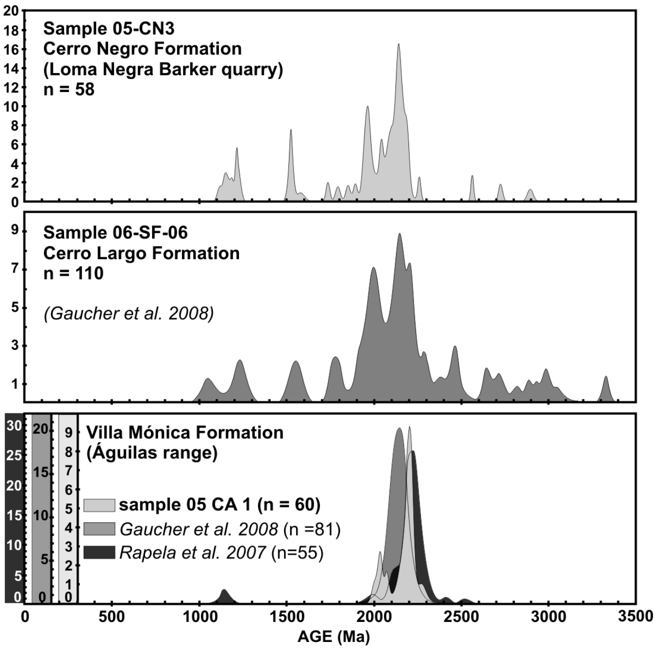

Figure 3: Comparative U–Pb provenance patterns for sedimentary samples from the Tandilia belt. The curves are relative probability trends. Data in stratigraphical relative position from base to top are based on Rapela *et al*. (2007); Gaucher *et al*. (2008), and the obtained in this work.

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